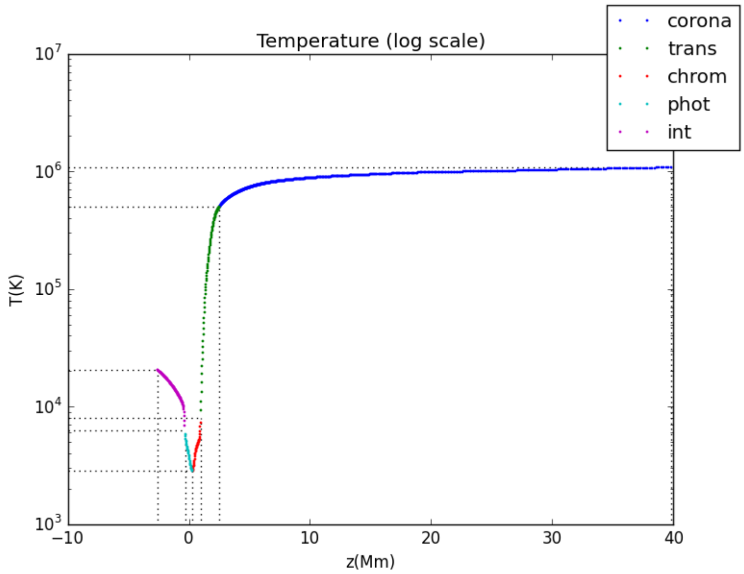


Figura 1: *Temperature vs z plot. logarithmic y scale*

**1a)** In order to identify the layers I put conditions on temperature:
`http://www.nasa.gov/mission_pages/iris/multimedia/layerzoo.html`

Looking at the values from the file 'atmosphere.dat' ordered by height from top(of the atmosphere) to bottom I consider the corona while temperature $\geq$ 500000 K (T is decreasing), transition region until T = 8000 K, the chromosphere until T reaches the (only) minimum, afterwards the temperature starts to raise and I consider the layer before it reaches 6500 K the photosphere and the solar interior after

The exact values matching these conditions are:

corona between [39.802200, 2.535930] Mm temperatures: [1.080180e+06, 5.025160e+05] K

transition region between [2.516350, 0.991115] Mm temperatures: [4.991350e+05, 8.067640e+03] K

chromosphere between [0.971556, 0.305708] Mm temperatures: [7.306160e+03, 2.843670e+03] K

photosphere between [0.286093, -0.303487] Mm temperatures: [2.848470e+03, 6.297540e+03] K

solar interior between [-0.323184, -2.592960] Mm temperatures: [6.837750e+03, 2.068340e+04] K

**1b)** $\mu = \frac{n_H + 4n_{He}}{n_e + n_H + n_{He}}$

$n_H = 10 n_{He} \implies \mu = \frac{1.4 n_H}{n_e + 1.1 n_H}$

- totally ionized H and He $\implies n_e = n_H + 2n_{He} = 1.2 n_H \implies \frac{n_H}{n_e} = \frac{5}{6}$ and $\mu = 0.6987$
- neutral H and He $\implies n_e = 0 \implies \mu = 1.2727$

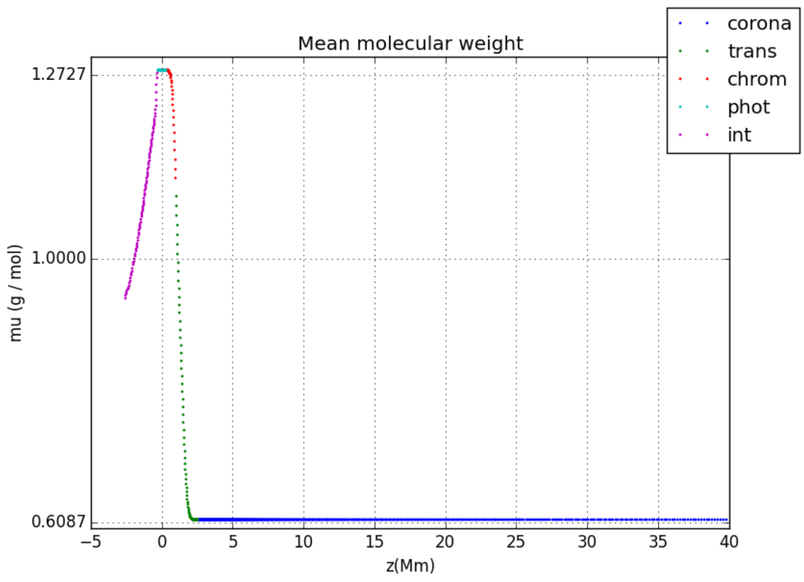


Figura 2: *Mean molecular weight(g/mol) vs z plot* Maximum close to 1.2727 = $\mu$ in the case of neutral H and He and minimum close to 0.6087 = $\mu$ calculated in the case of completely ionized H and He

$\frac{n_H}{n_e} = \frac{\mu}{1.4 - 1.1\mu}$

In the case of neutral H and He $n_e \to 0 \implies \frac{n_H}{n_e} \to \infty$

When plotting $\frac{n_H}{n_e}$ using $\mu$ from the file, as we can see in the graphic of $\mu$ there are some values of z for which $\mu > 1.2727 \implies 1.4 - 1.1\mu < 0 \implies \frac{n_H}{n_e} < 0$

I will limit oy axis values to $[0, 4]$

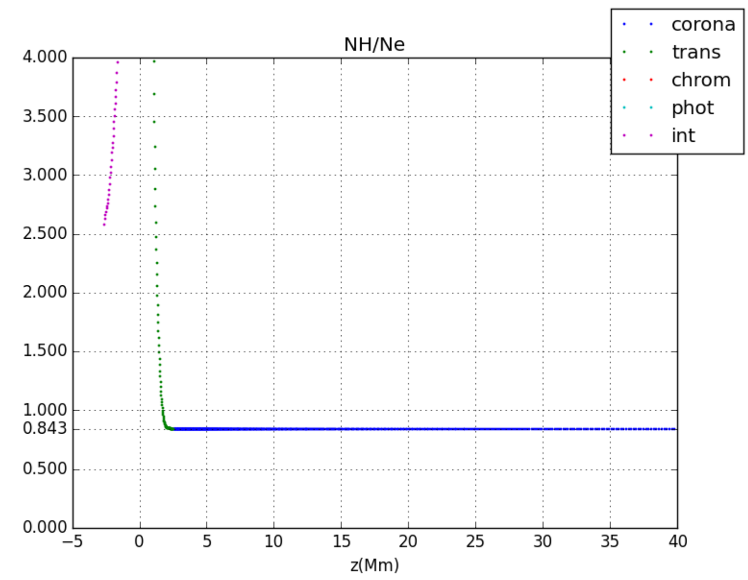


Figura 3: number of atoms of H / number of electrons

We can see a constant value of $\frac{n_H}{n_e}$ in the corona of $\frac{n_H}{n_e} = 0.843 \approx \frac{5}{6}$ which is the value we calculate in the case of totally ionized H and He and we expect this because of the high values of the temperature in the corona

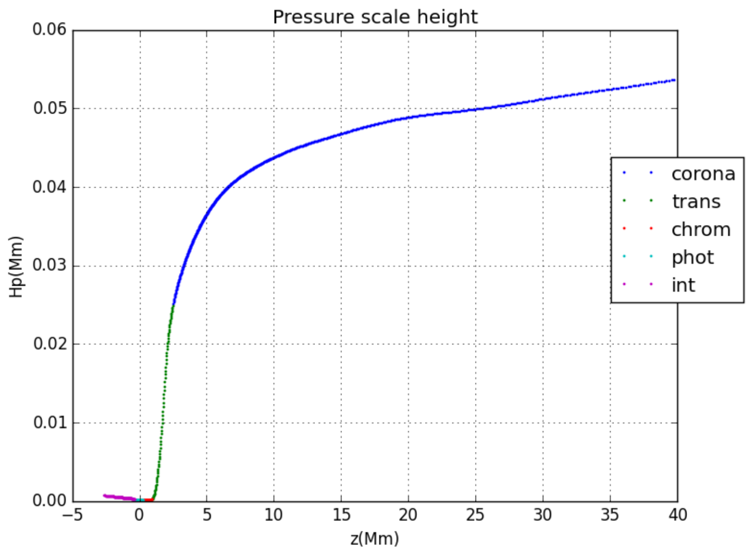


Figura 4: Pressure scale height

**2)** $\frac{d\ln p}{dz} = -\frac{1}{H_p}$, $H_p$ const $\implies$ ln $p(z)$ - ln $p(z_0) = -\frac{1}{H_p}(z - z_0) \implies p(z) = p(z_0)exp(-\frac{z-z_0}{H_p})$

$\rho(z) = \frac{1}{gH_p}p(z) = \frac{p(z_0)}{gH_p}exp(-\frac{z-z_0}{H_p}) = \rho(z_0)exp(-\frac{z-z_0}{H_p})$

Analytic test for $H_p$ constant (with values 1 and $1e10$) with $\rho(z_{max})$ taking values: $1e-10, 1e-5, 1e-2, 1, 1e2, 1e3, 1e7, 1e10$ Integrating downward or forward in height makes no difference (using ln p)

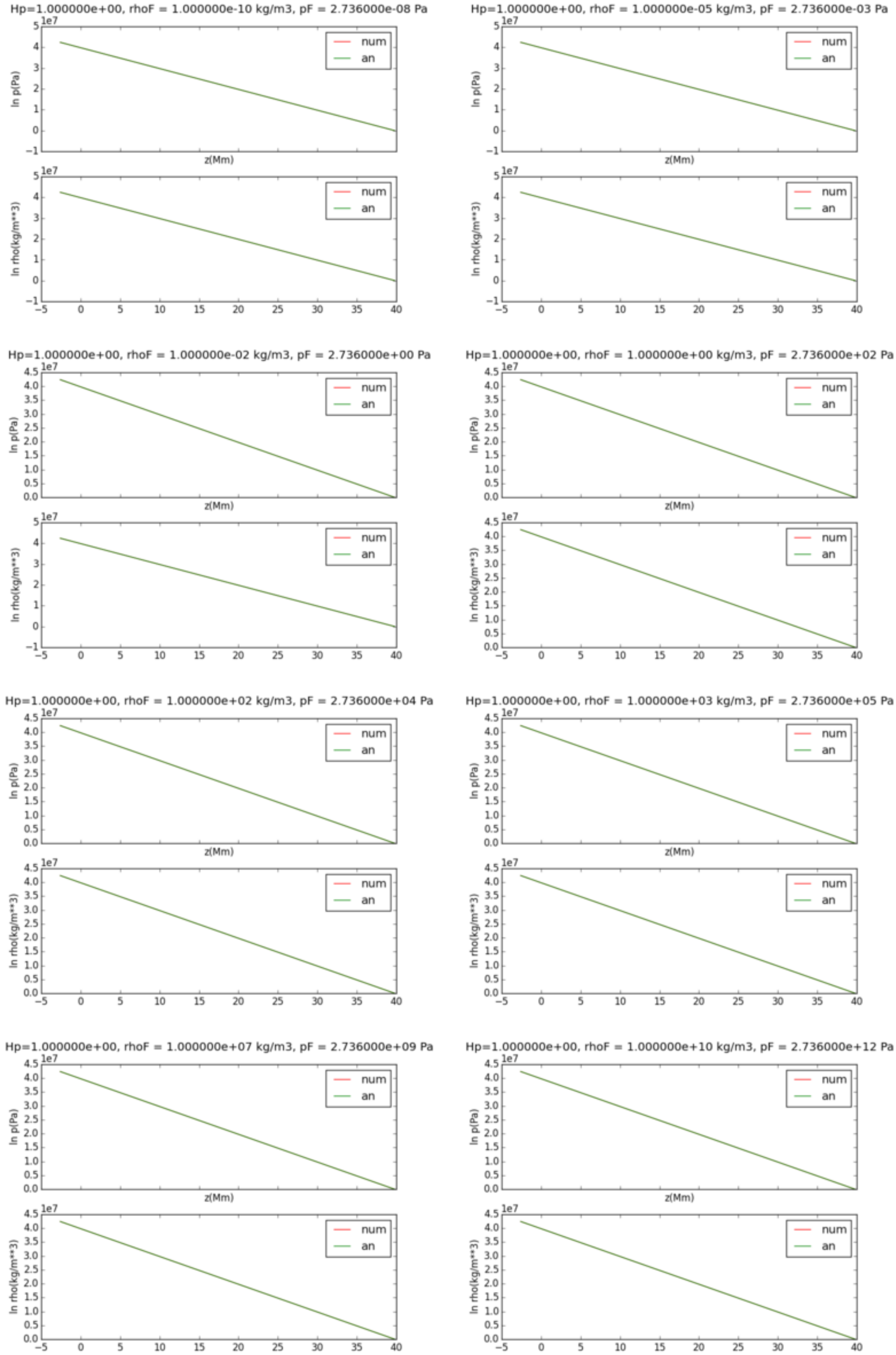


Figura 5: Analytic test Hp=1

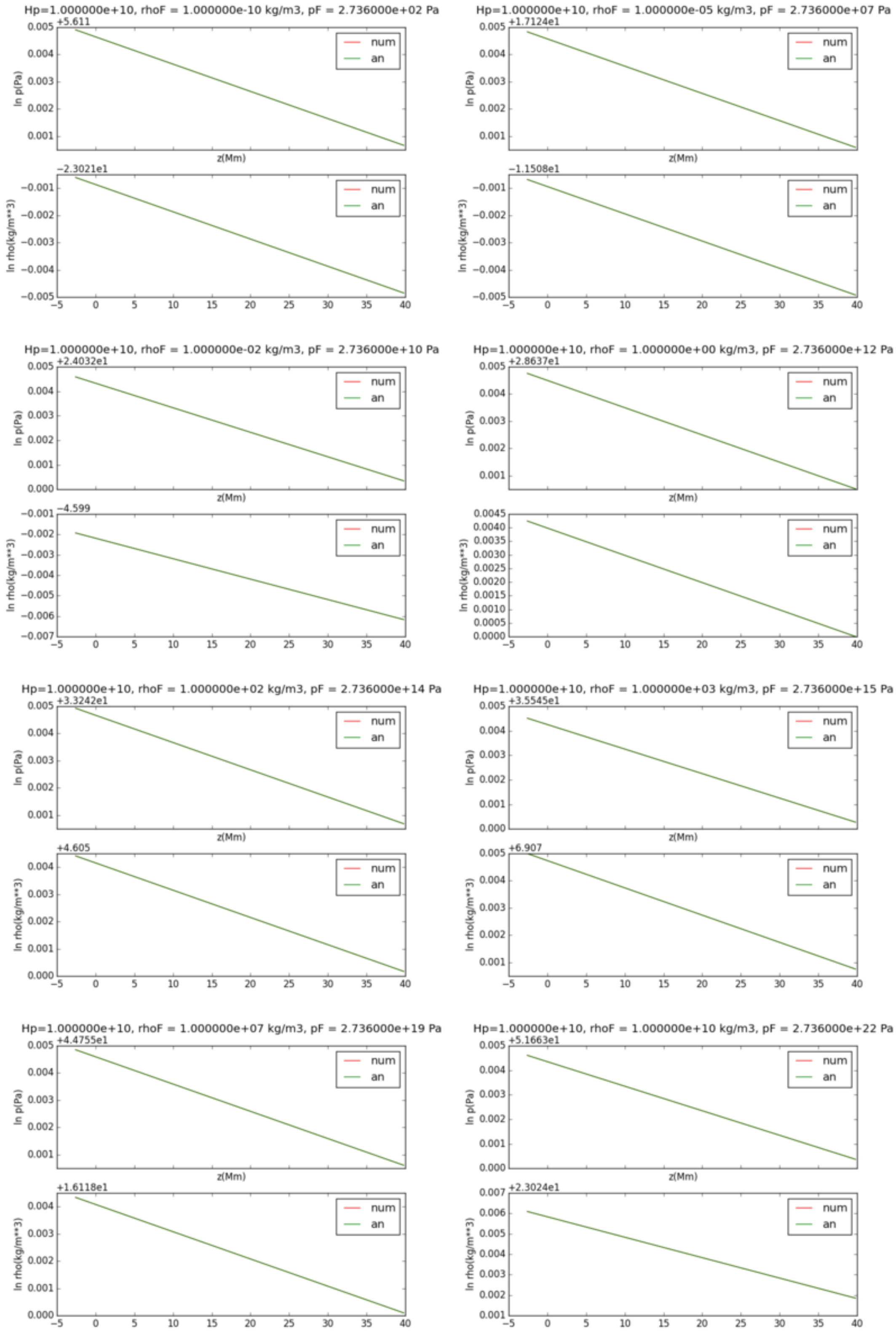


Figura 6: Analytic test Hp=1e10

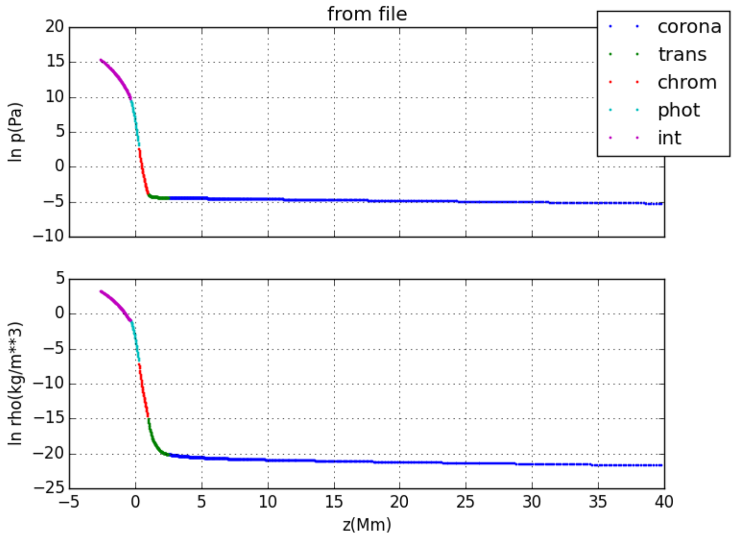


Figura 7: logarithmic (base e: ln) of pres, rho

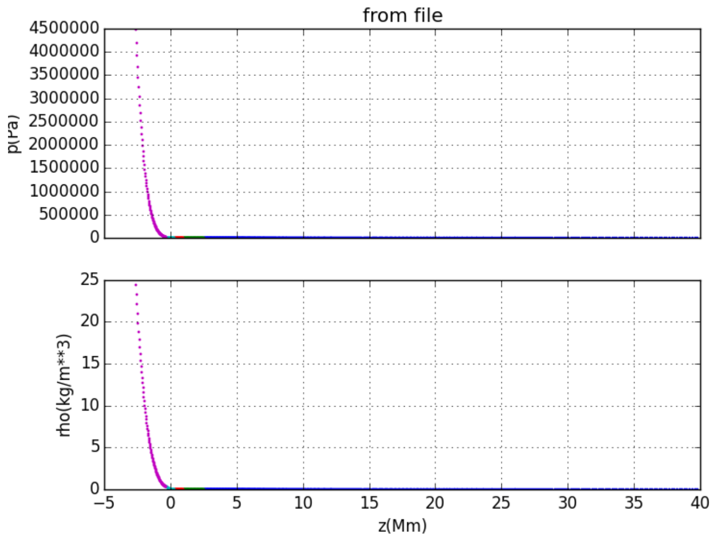


Figura 8: pres, rho

Notation: $\mu_0$ = magnetic permeability
$\beta = \frac{p}{p_{mag}}$ where $p_{mag} = \frac{B^2}{2\mu_0}$
$v_A = \frac{B^2}{\mu_0 \rho}$
$c_s = \sqrt{\frac{\gamma p}{\rho}}$

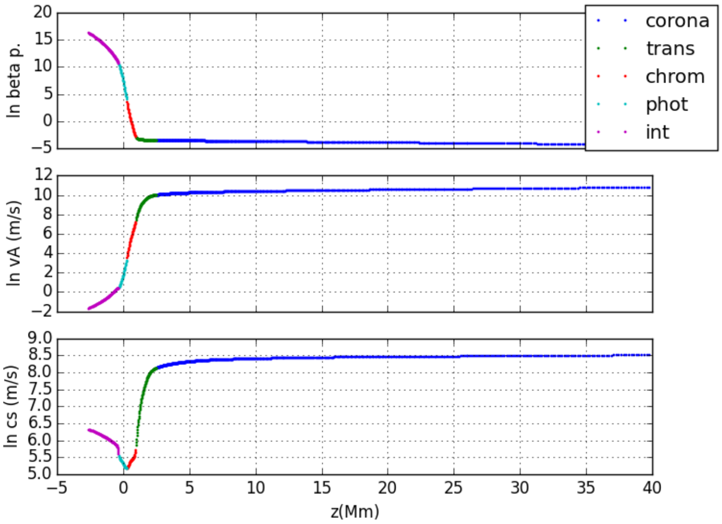


Figura 9: logarithmic (base e: ln) of beta plasma, vA, cs

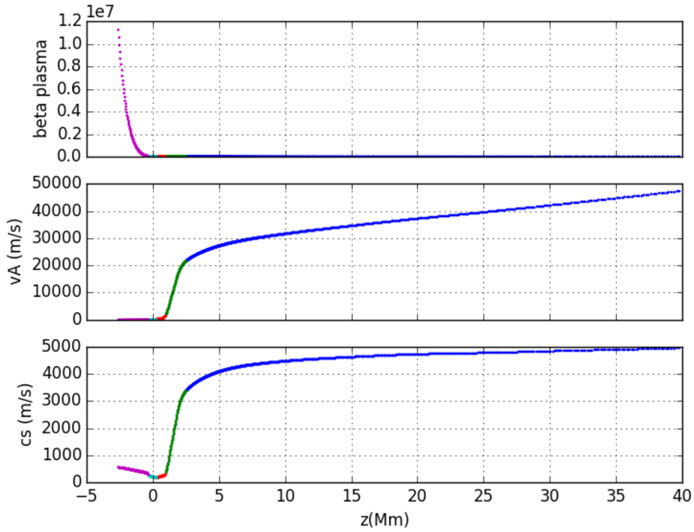


Figura 10: beta plasma, vA, cs

$\beta = \frac{2p\mu_0}{B^2} = \frac{2p}{\rho v_A^2} = \frac{2}{\gamma}(\frac{c_s}{v_A})^2 \implies \beta(\frac{v_A}{c_s})^2\frac{\gamma}{2} = 1$ We call this function func($\beta, \frac{v_A}{c_s}$) in the graphic below and expect it to be 1

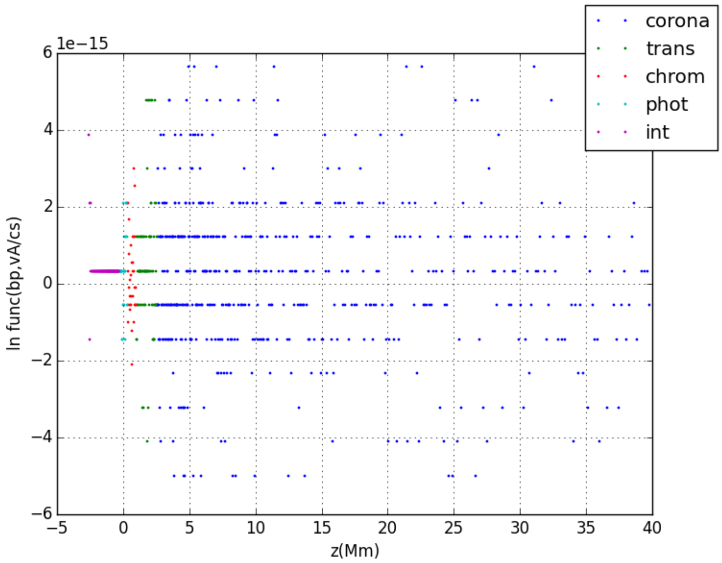


Figura 11: ln func(bp, vA/cs) $\approx 0$

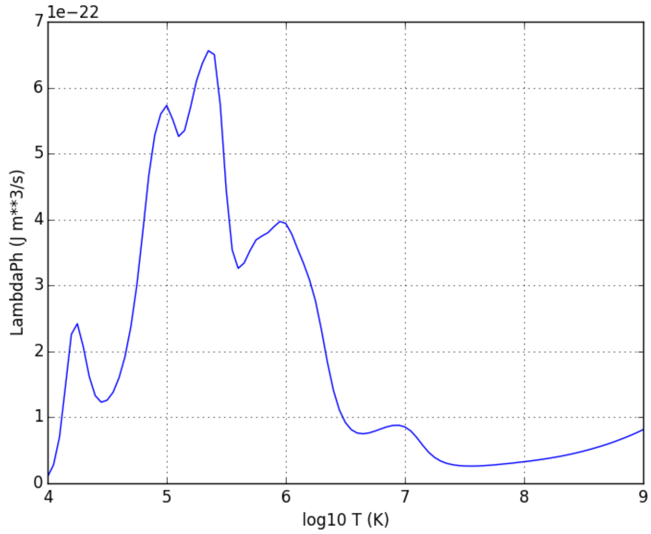


Figura 12: Lambda phot

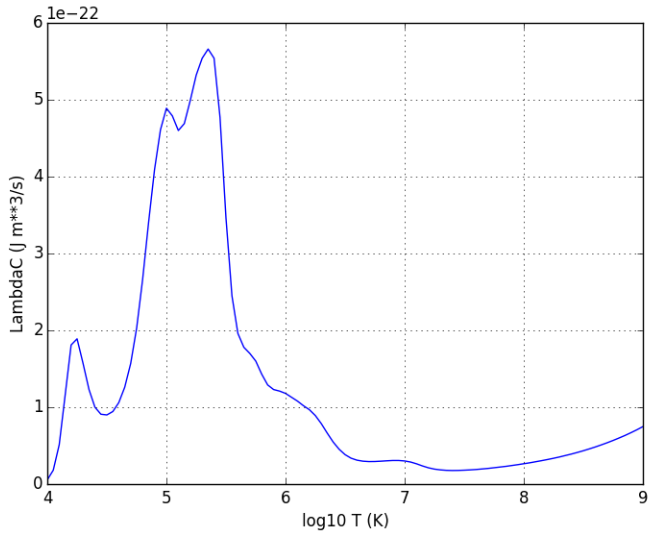


Figura 13: Lambda corona

**3a)** Both functions have the maximum for T = 2.238721e+05 K

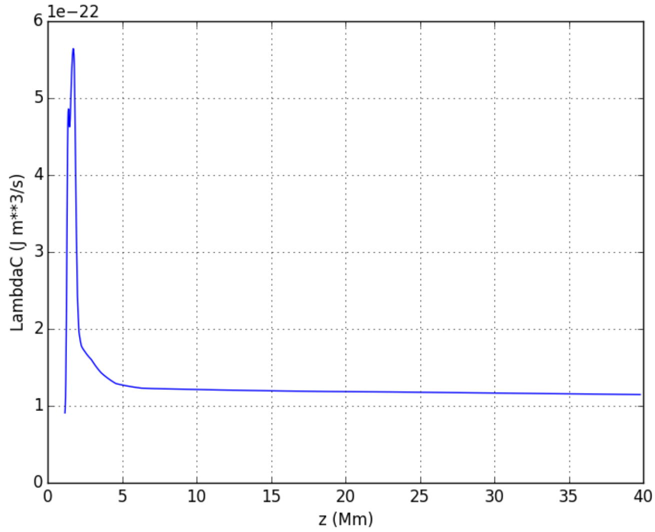


Figura 14: Lambda corona interpolated for atm. temperatures $> 3 * 10^4$ K in 'atmosphere.dat' plotted vs z

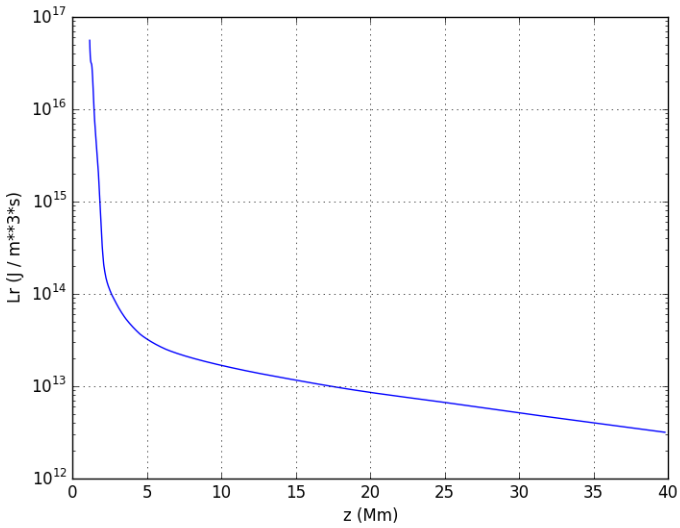


Figura 15: Lr logarithmic y scale

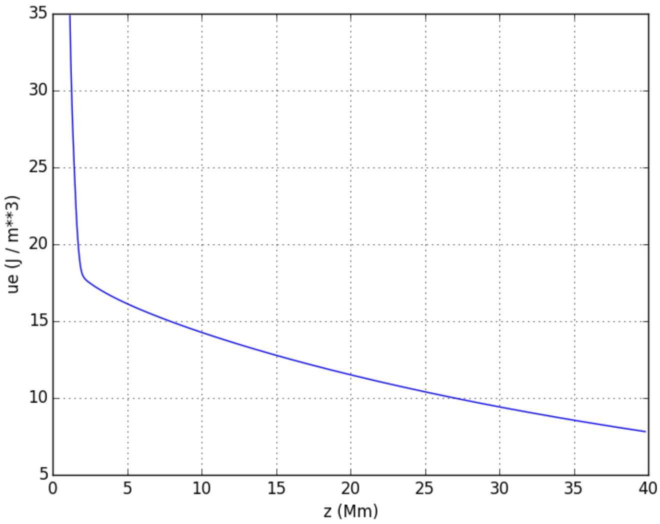


Figura 16: Internal energy

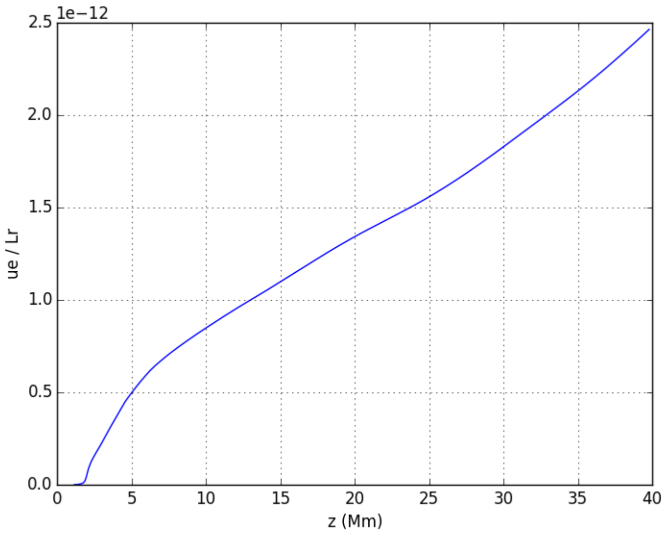


Figura 17: Internal energy / Lr